



Global study of Bright Band structure as observed from space-borne precipitation radar

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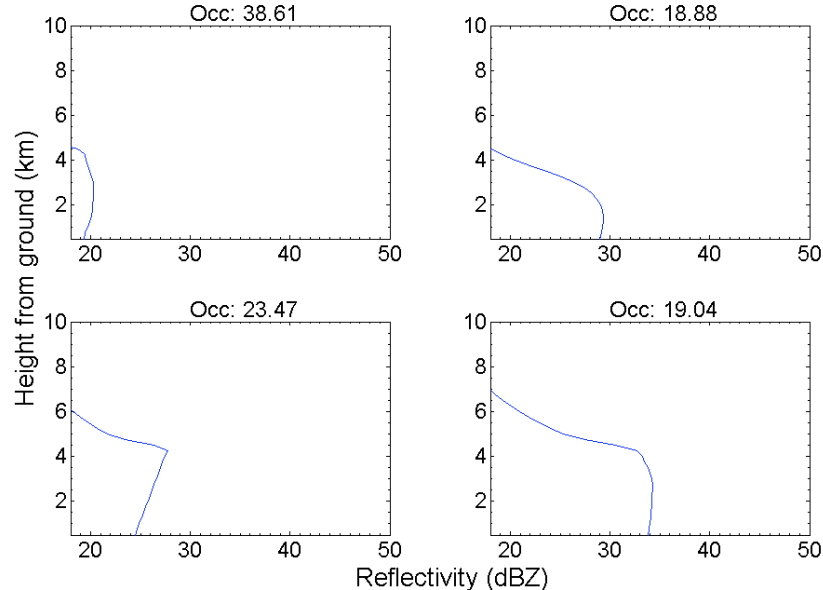


Z_{rain} : the reflectivity measured at 125 m.(one range bin) below the BB bottom height (h_{bot})

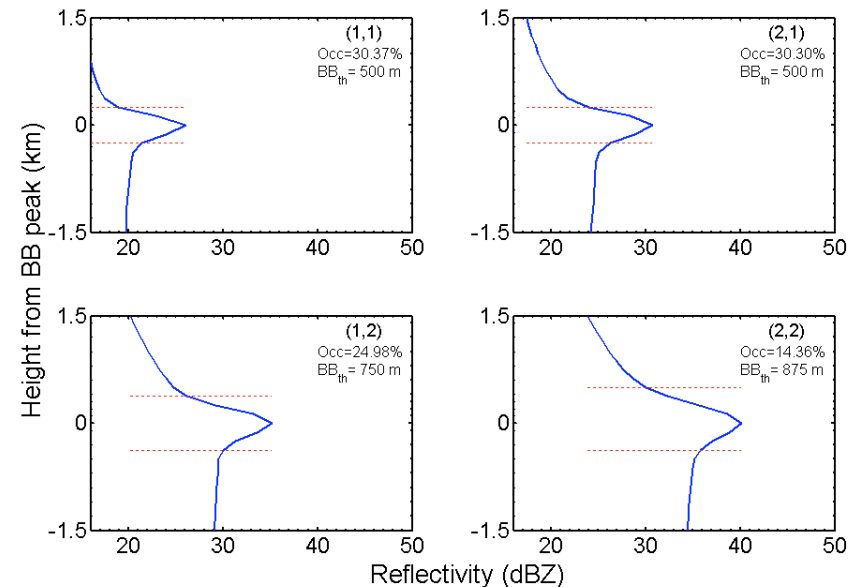


Global study of BB : Self Organizing Map (SOM)

- A SOM classification Scheme is used to analyze the BB structure during the year 2000.
- About 8.6 million profiles used for classification.
- The analysis is performed using two different reference points:
 - 1) Ground
 - 2) BB peak



SOM(2x2) classification results of BB structure using ground height as reference

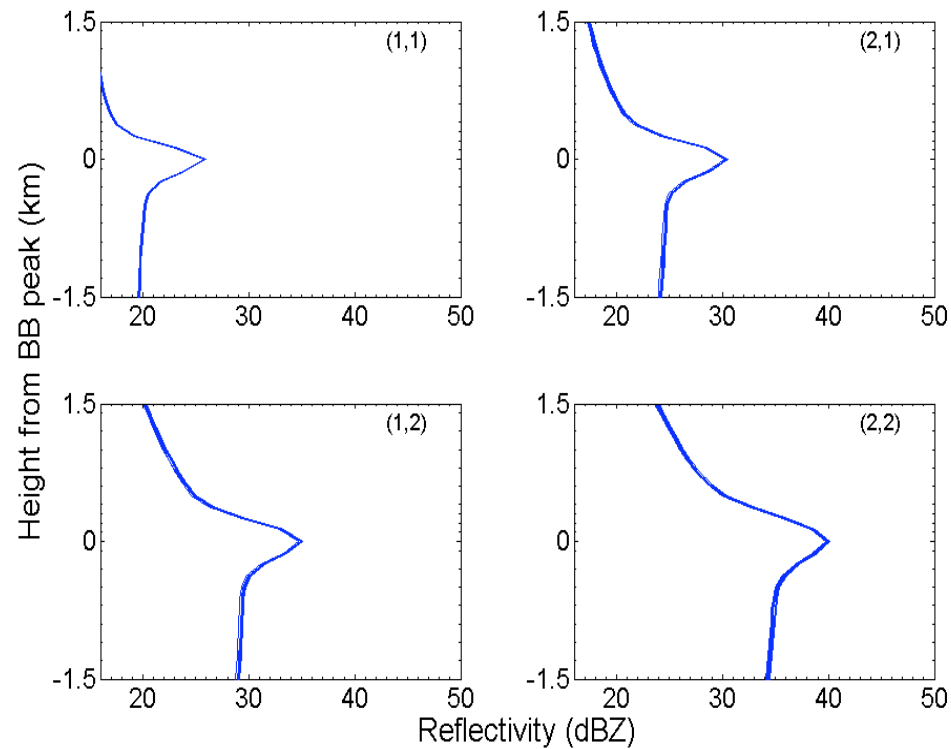


SOM(2x2) classification results of BB structure using BB peak height as reference

- As seen, using BB peak height as reference gives clearer BB structure.
- The rest of the slides are results of classifying BB reflectivity structure using BB peak height.



Monthly study

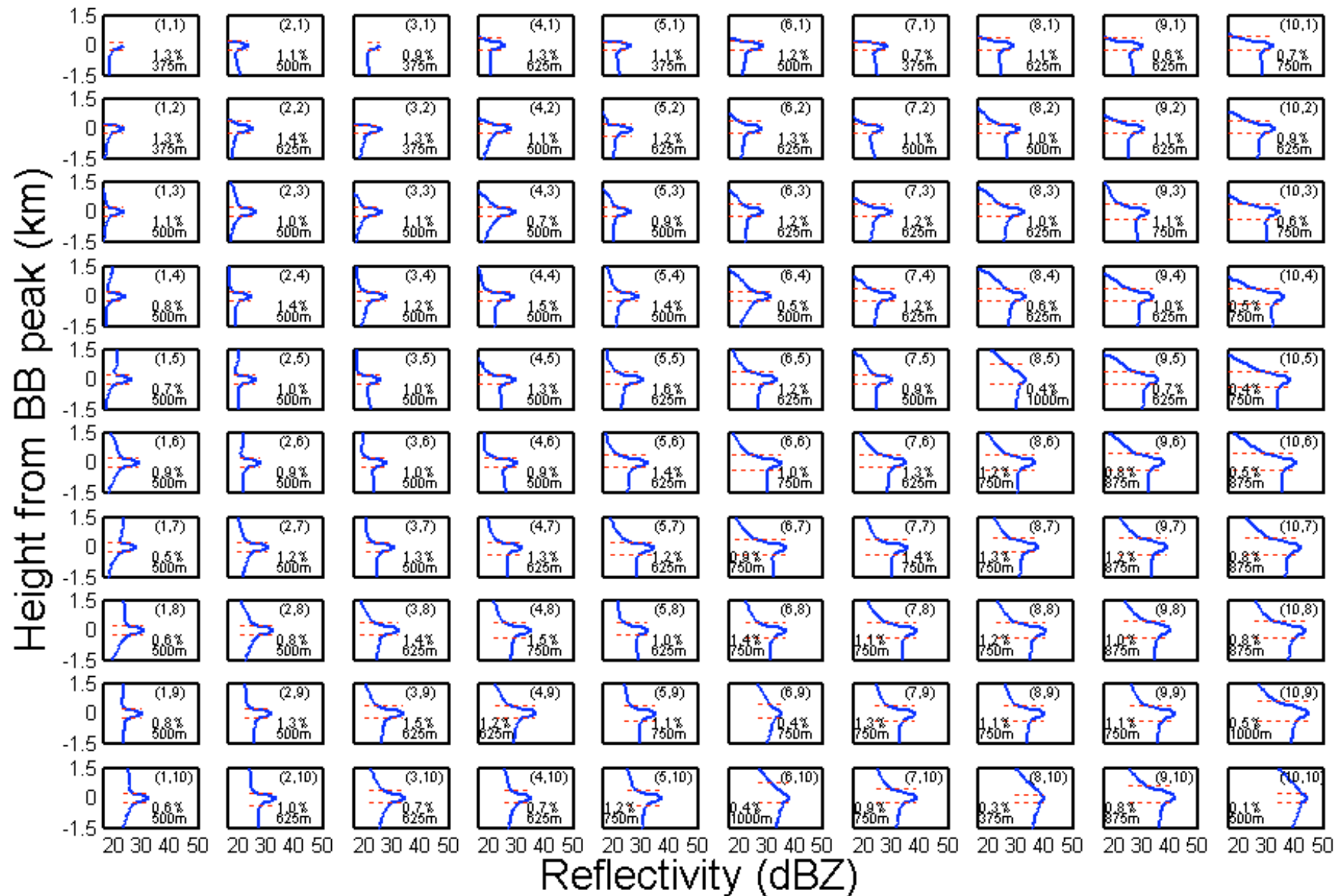


The classification result of 2x2 SOM for each month in year 2000

- Clearly, the reflectivity structures of all months in year 2000 are almost the same (There are 12 overlapping curves)

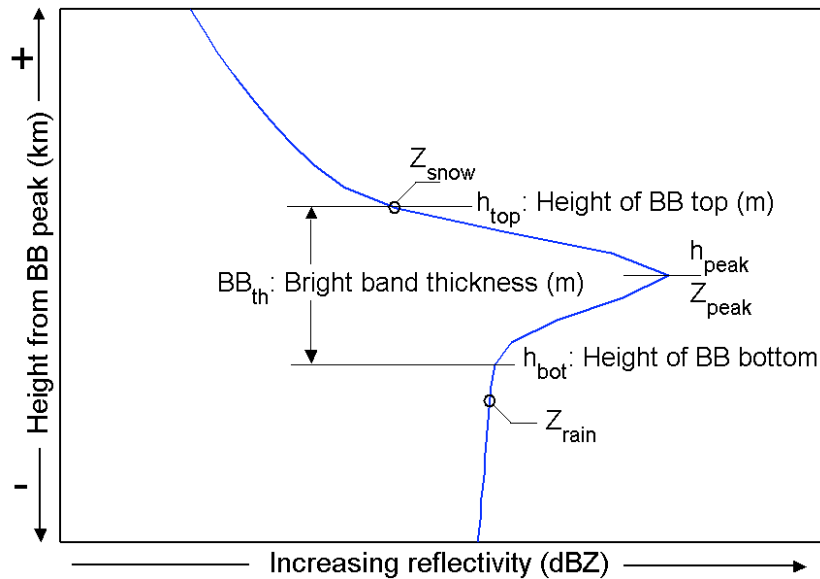


10x10 SOM classification results for year 2000





Study of BB properties

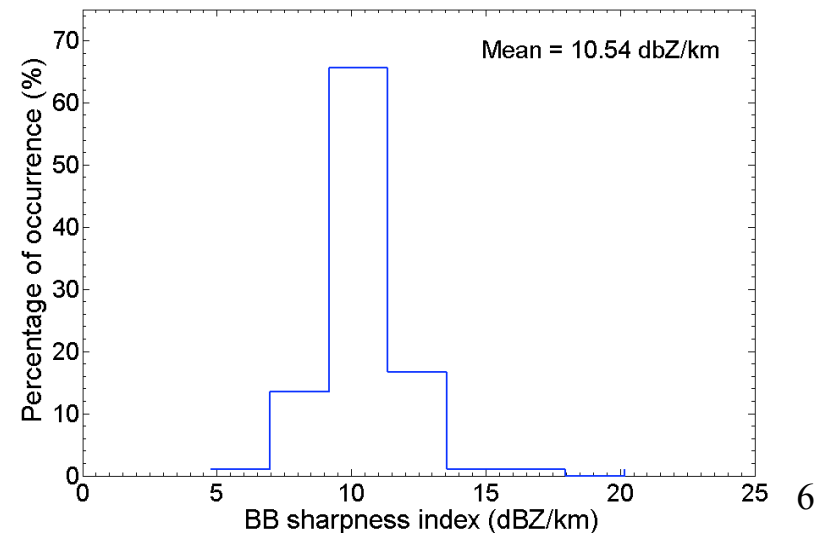
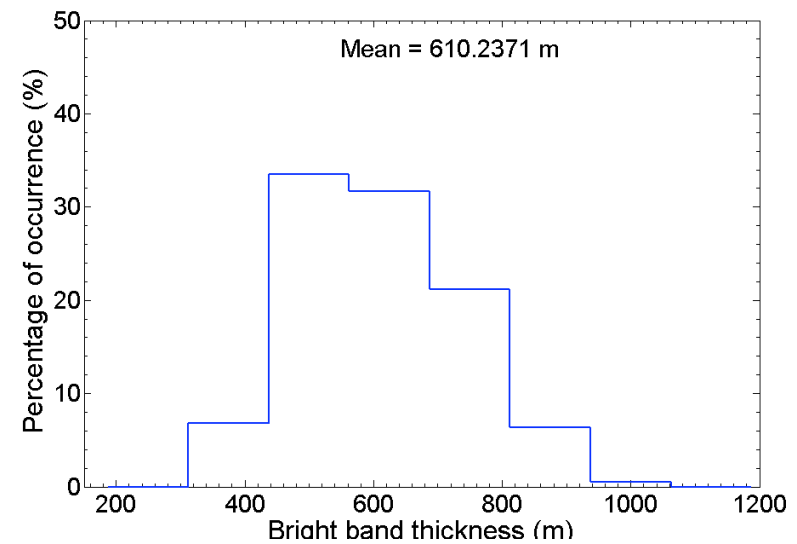


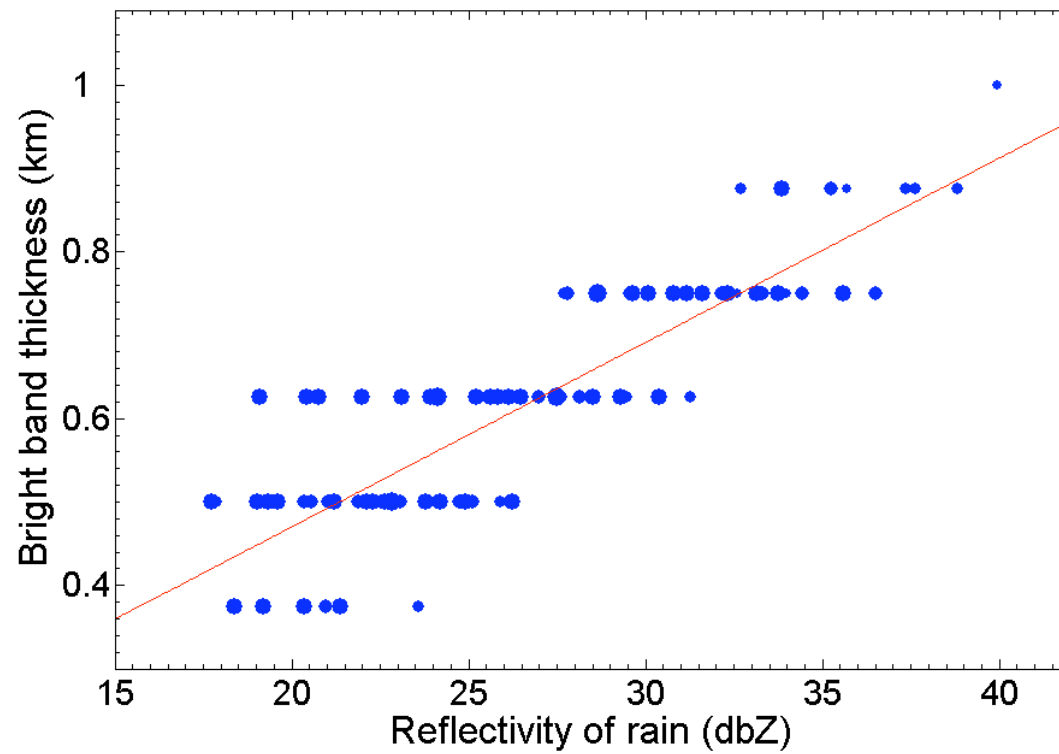
$$\text{BB thickness (BB}_{th}) = h_{top} - h_{bot}$$

$$\text{BB sharpness index} = \frac{Z_{bb}}{\text{BB}_{th}}$$

where $_{Z} = ((Z_{peak} - Z_{rain}) + (Z_{peak} - Z_{snow})) / 2$

Histogram BB thickness and BB sharpness index for year 2000





➤ Reflectivity increases as bright band thickness is increasing.

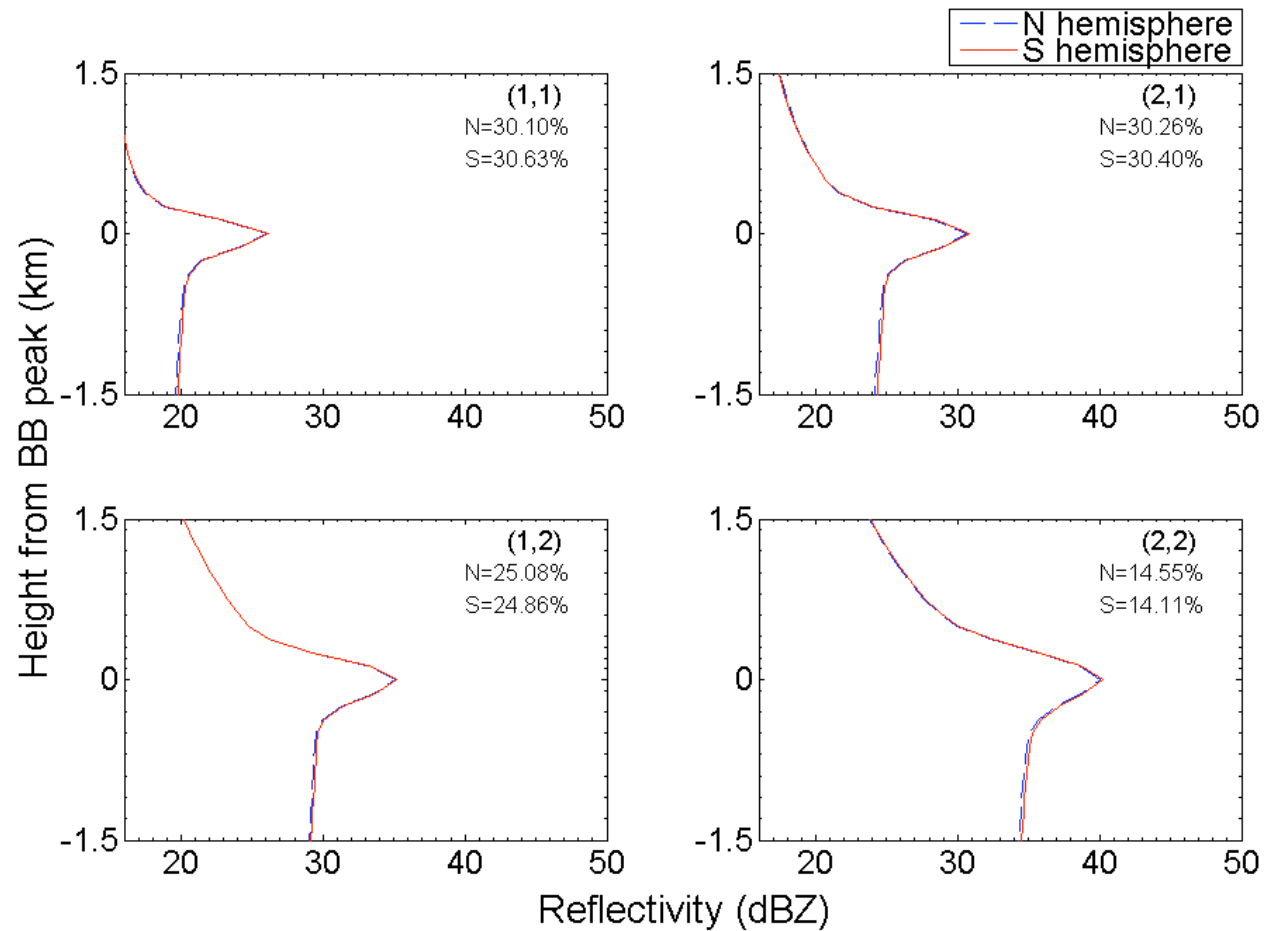


Comparative study of BB structure

- 1) Northern vs Southern hemisphere
- 2) Land vs Ocean
- 3) East vs West Pacific Ocean



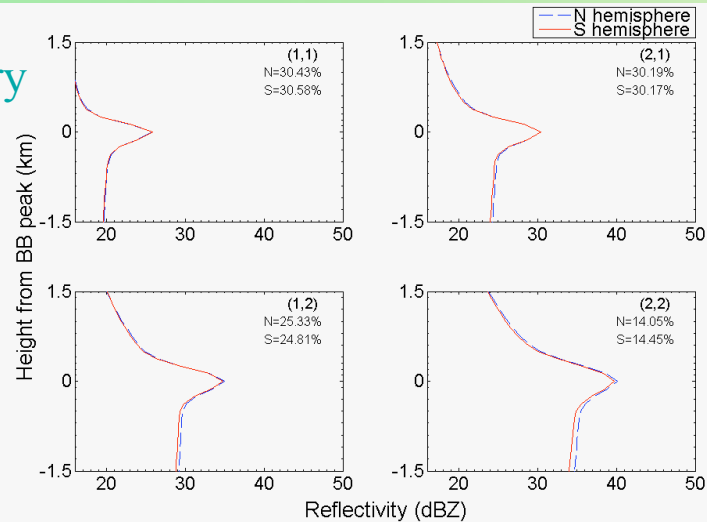
1) Northern vs Southern hemisphere



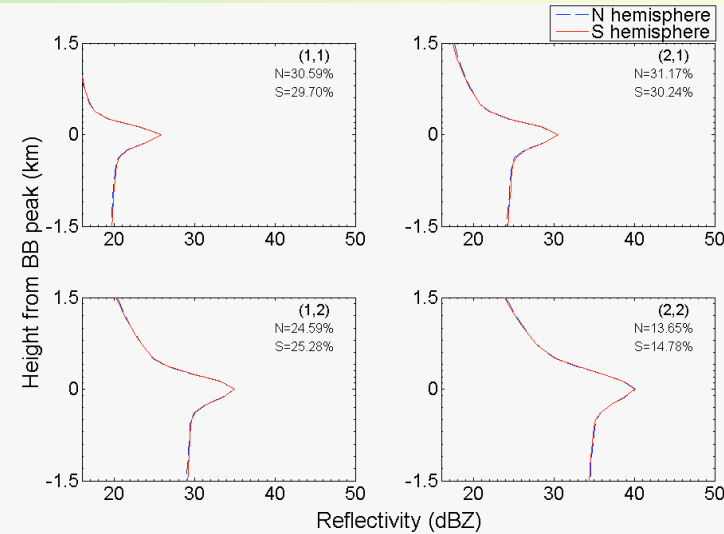
- No difference in 2x2 SOM classification for BB structure between northern and southern hemisphere in year 2000



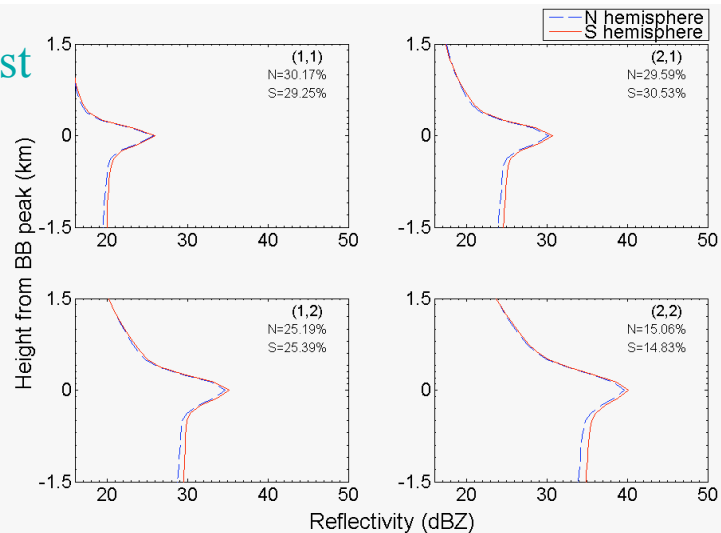
January



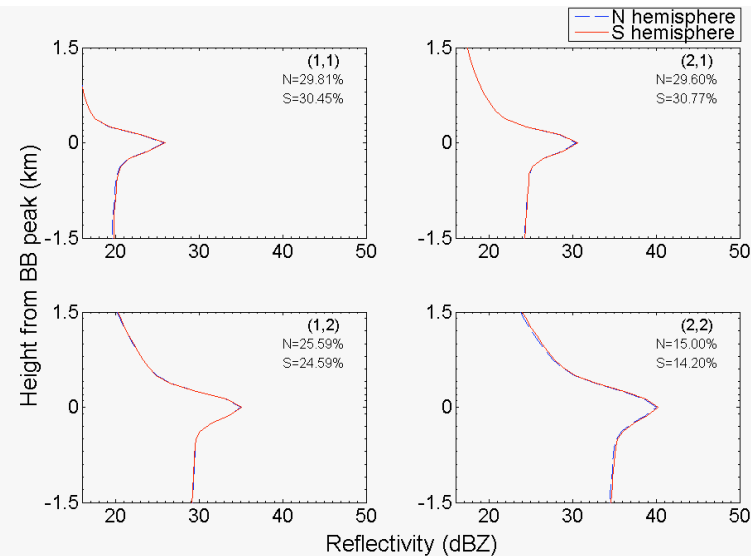
April



August



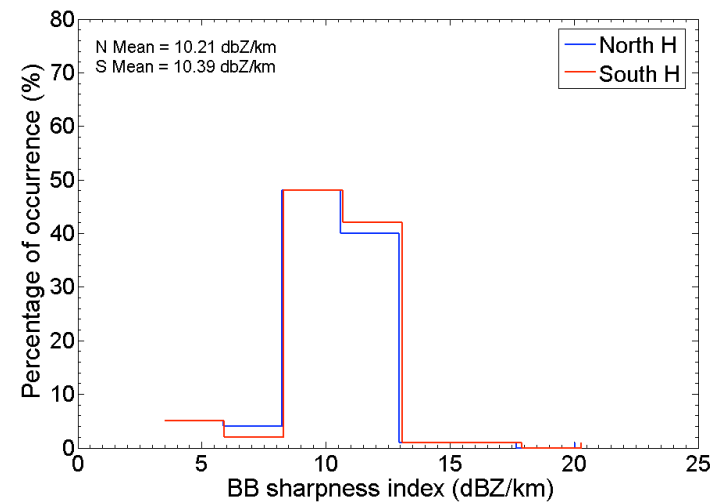
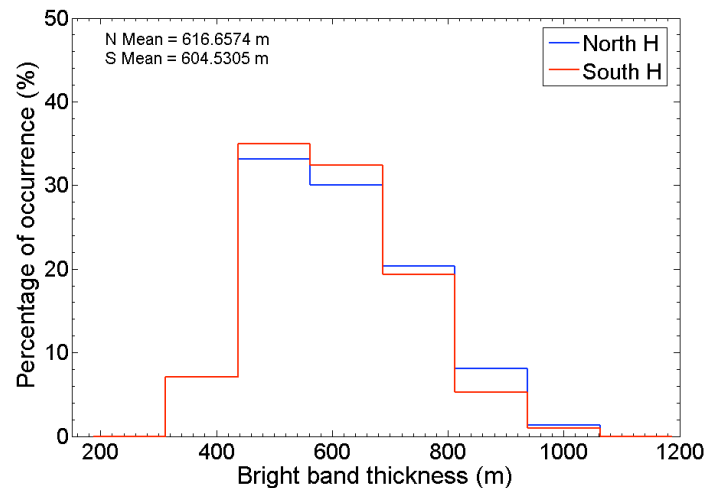
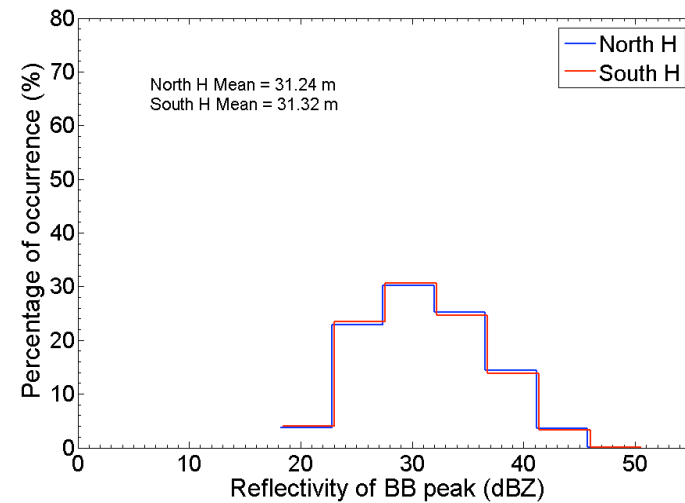
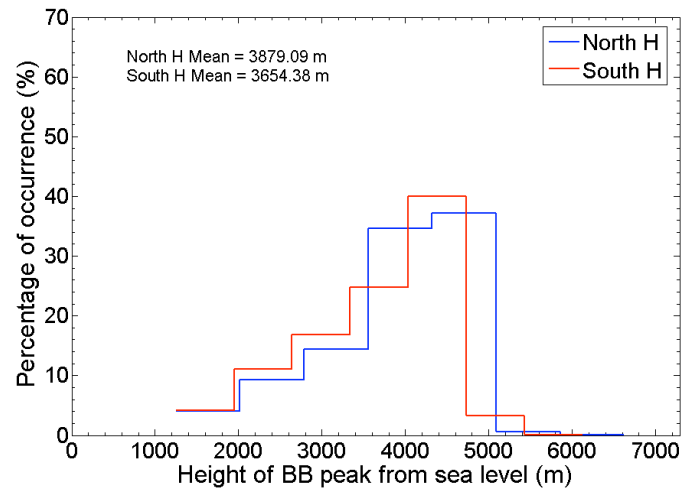
November



- There are slightly difference of reflectivity below BB peak height between northern and western hemisphere in January and August of year 2000

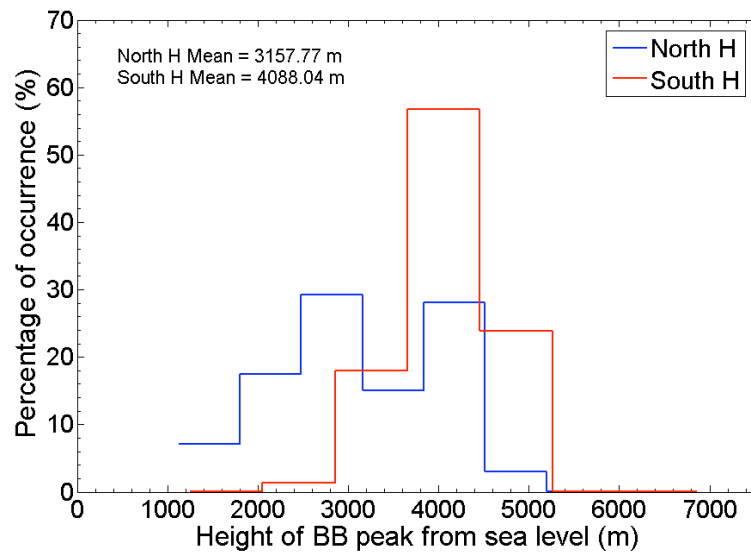


Comparison BB properties between Northern and Southern Hemisphere in year 2000



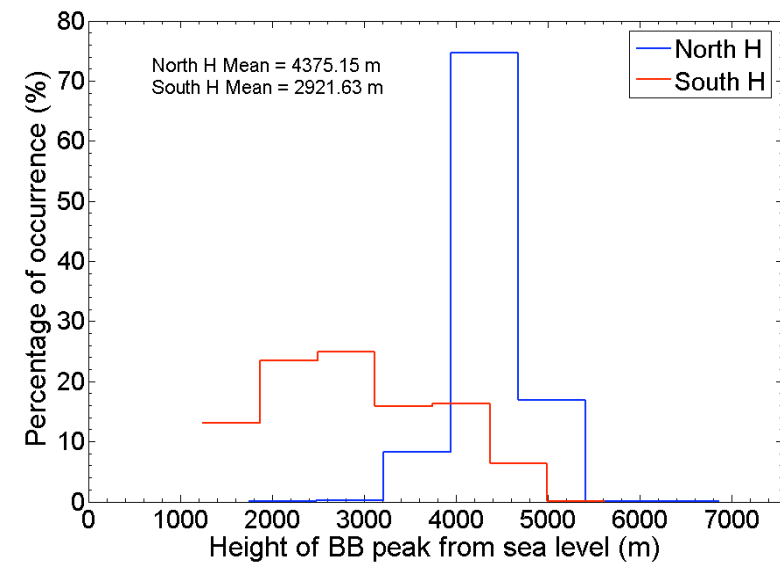


January



North H = 3157 m.
South H = 4088 m.

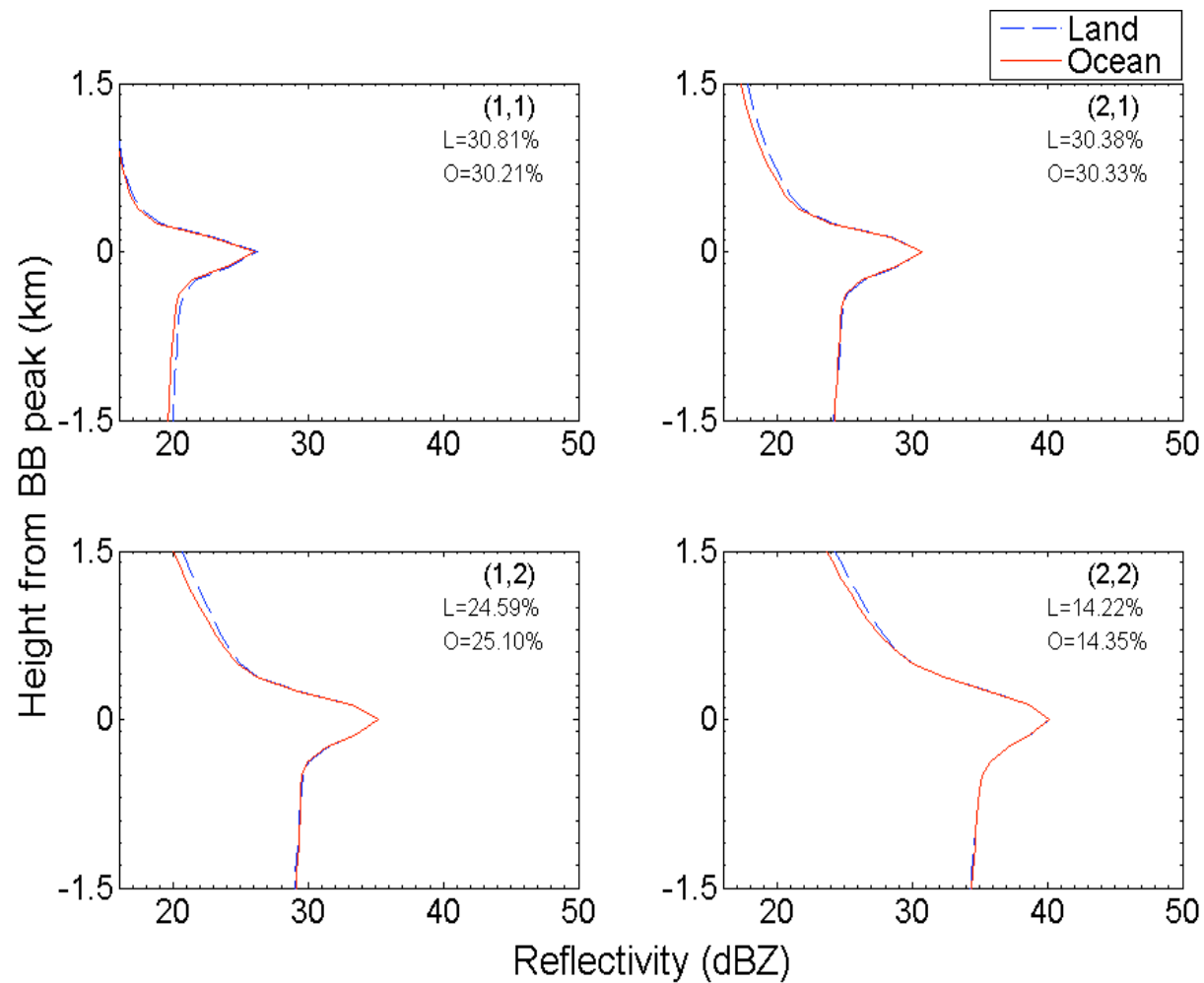
August



North H = 4375 m.
South H = 2921 m.



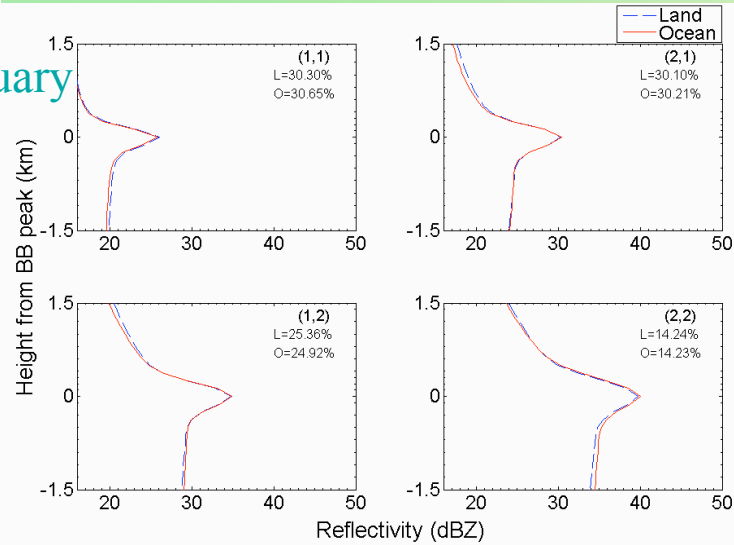
2) Land vs Ocean



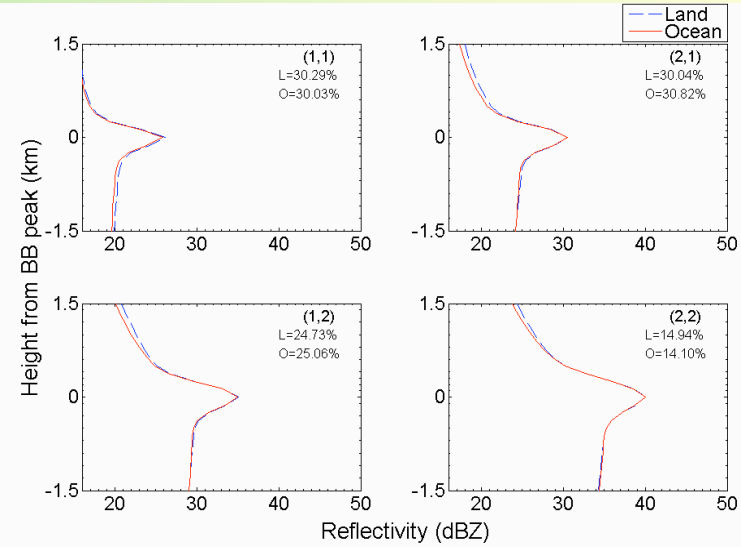
➤ No significant difference between Land and Ocean in year 2000



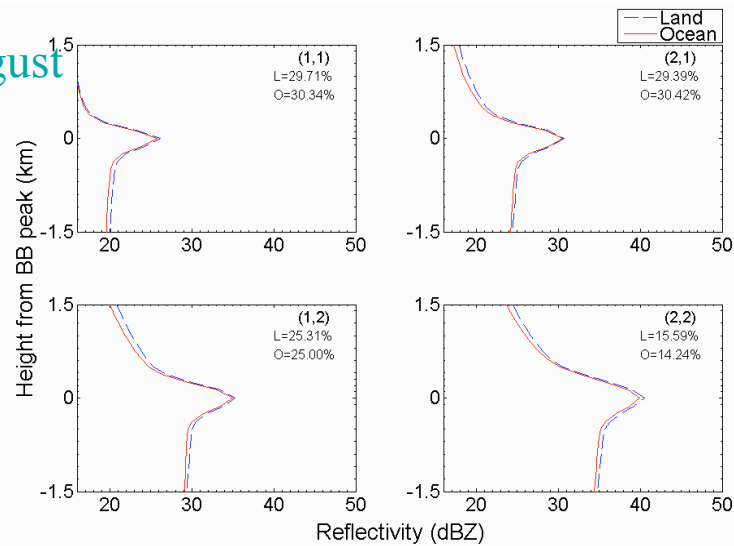
January



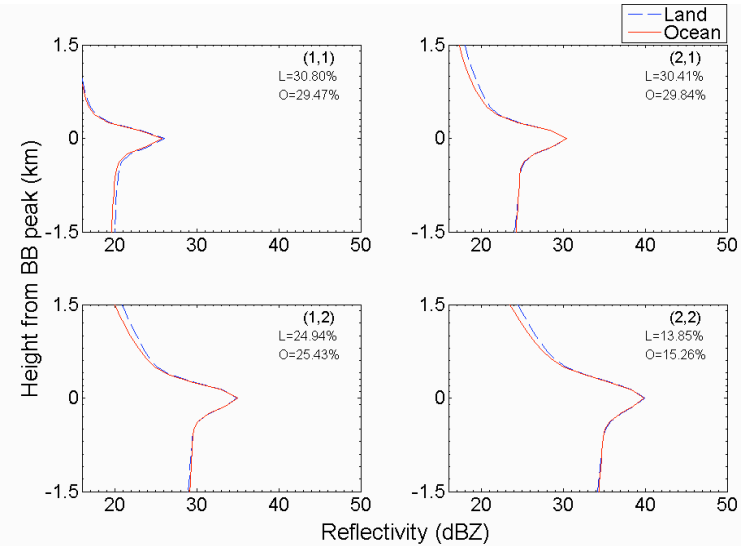
April



August



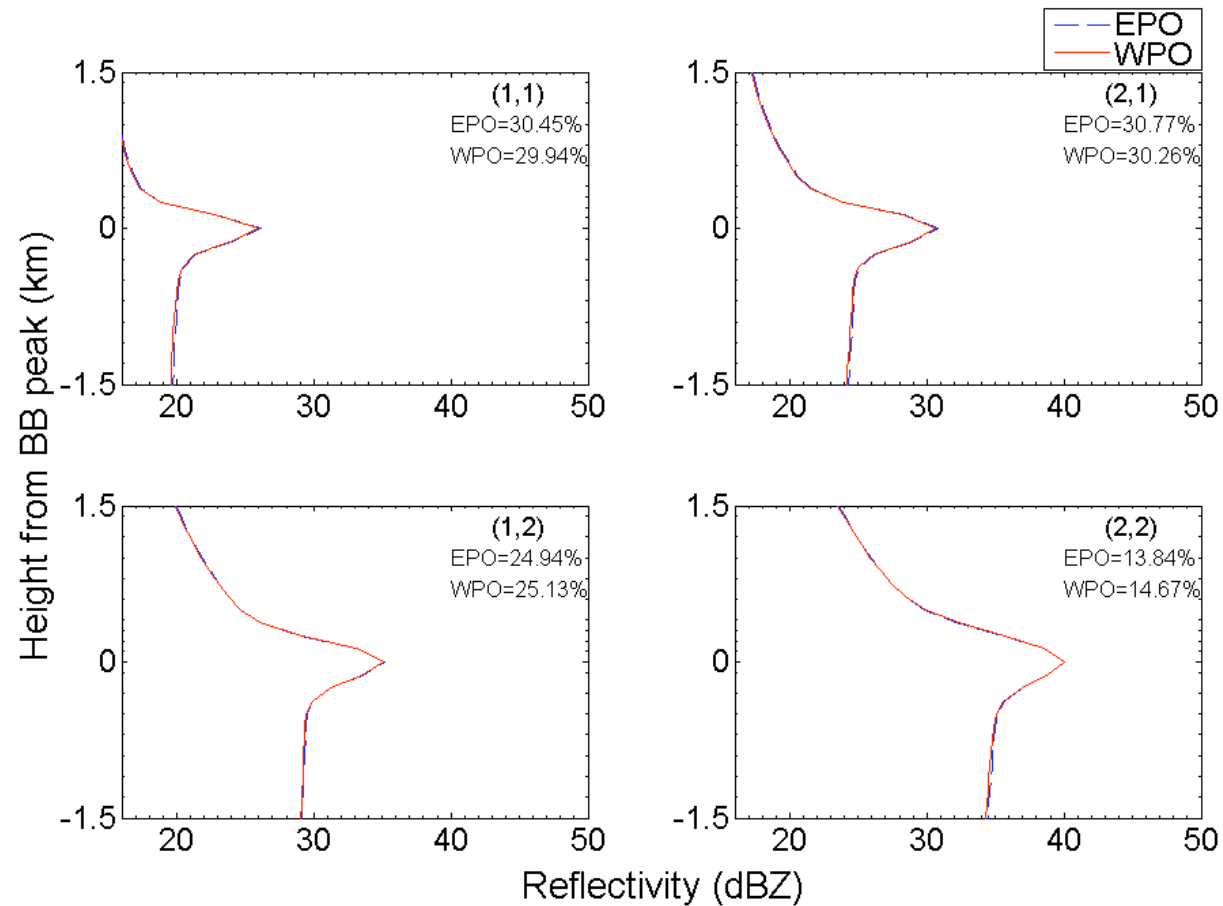
November



➤ No significant seasonal difference between land and ocean in year 2000



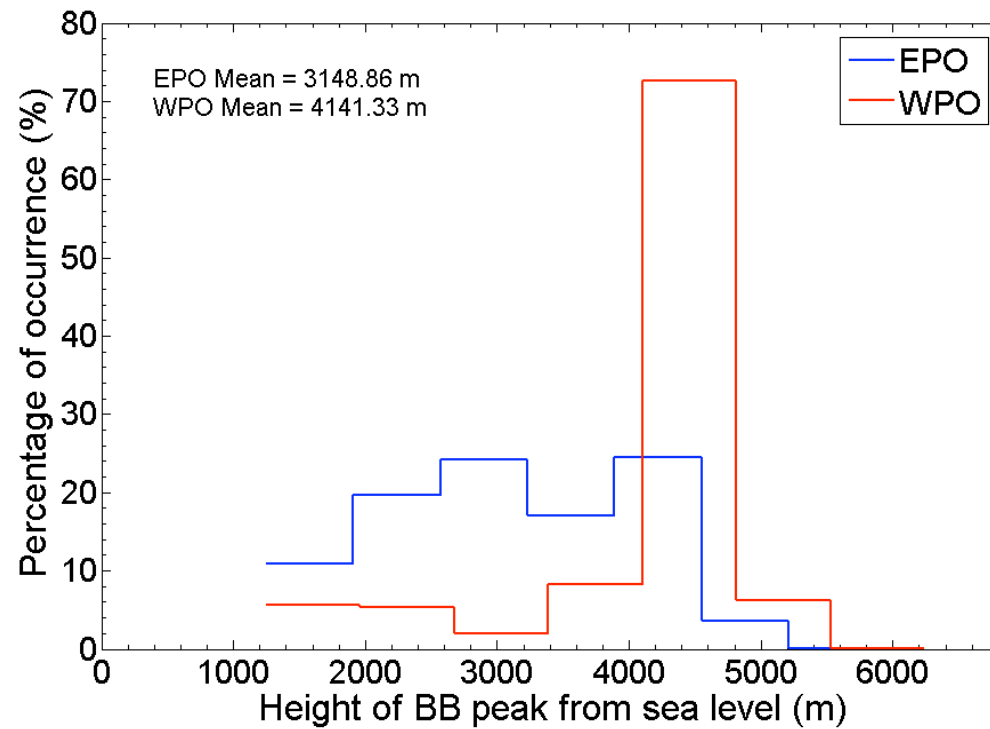
3) East vs West Pacific Ocean



➤ No difference between East vs West Pacific Ocean in year 2000



August



East Pacific Ocean : 3148 m.

West Pacific Ocean : 4141 m.



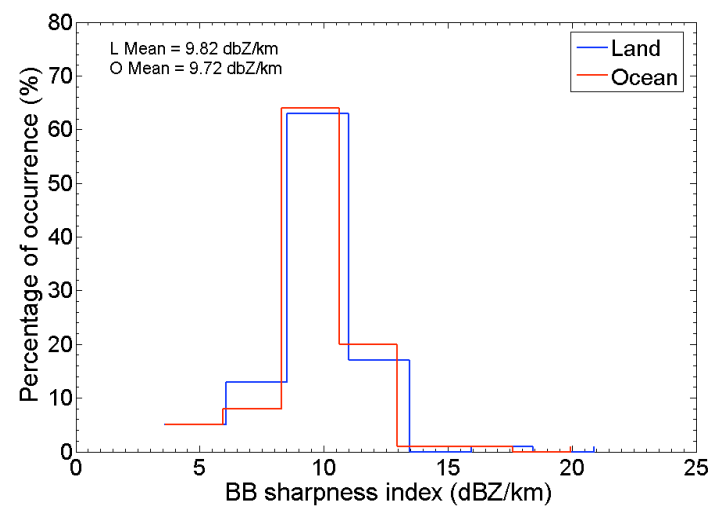
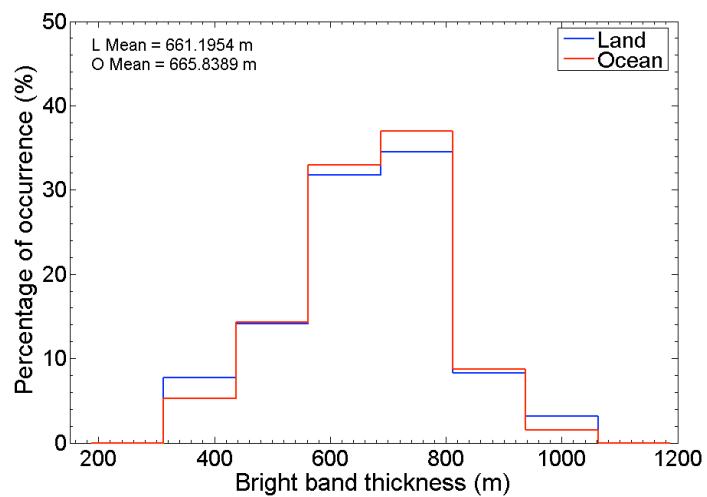
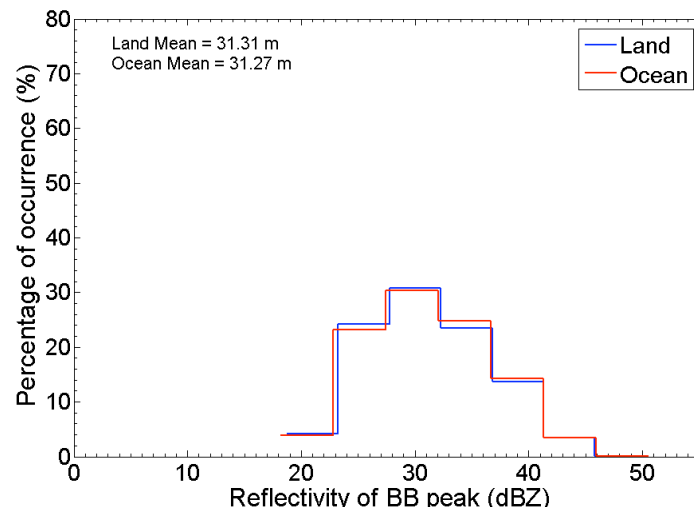
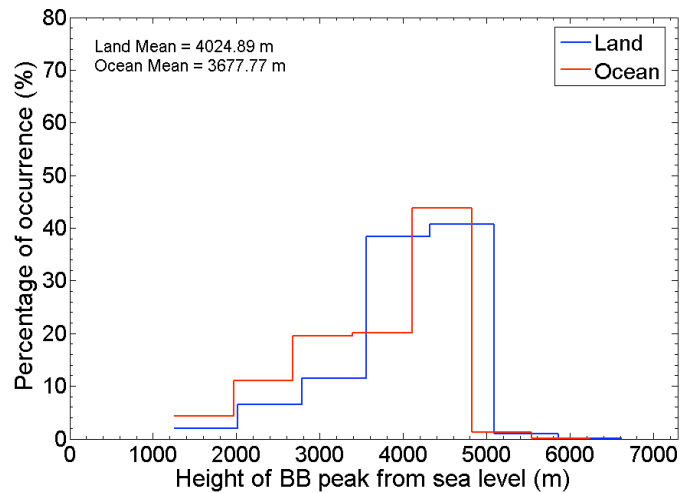
- ❑ Globally Bright band structure is
INVARIANT
- ❑ Most of the variability in Bright band is in
its height.
- ❑ Bright band structure is analyzed many ways
Monthly,
Northern vs Southern hemisphere,
Land vs ocean,
East vs West Pacific Ocean.



Backup slides

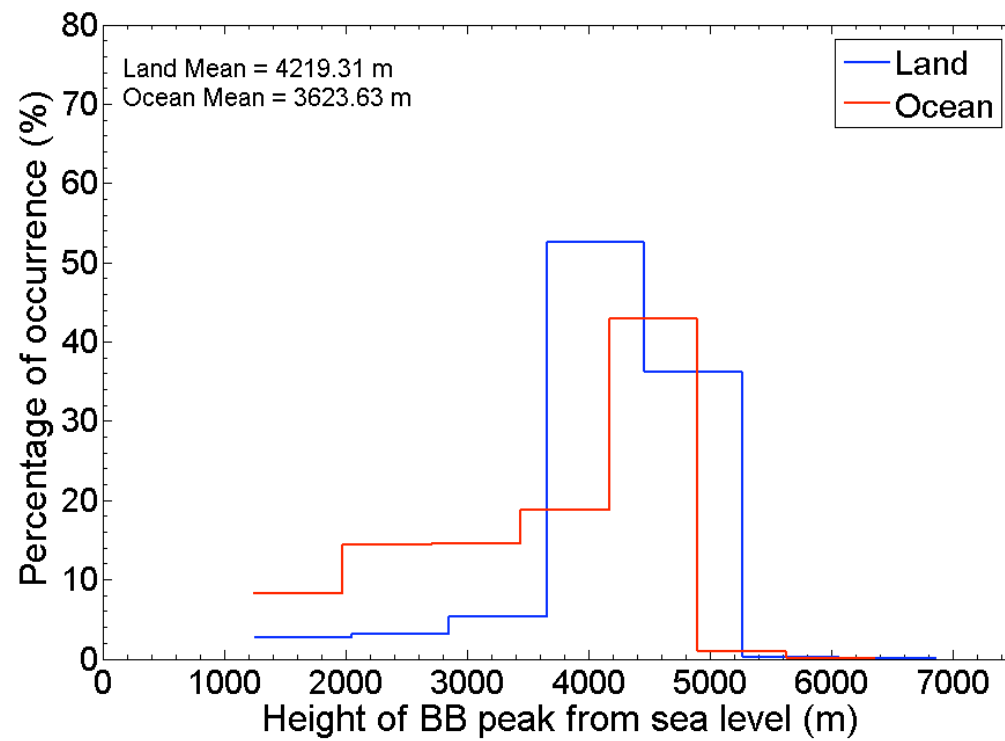


Comparison BB properties between land and Ocean in year 2000





August

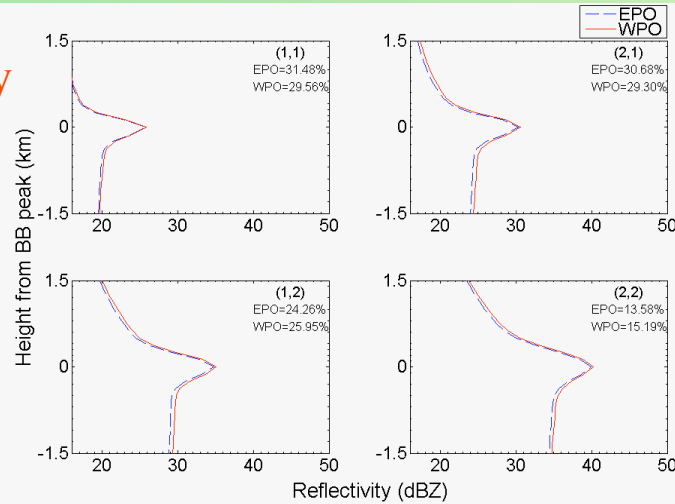


Land : 4219 m.

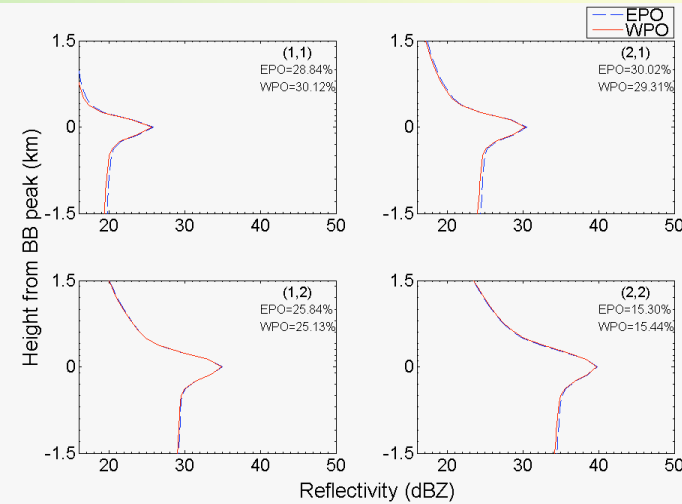
Ocean : 3623 m.



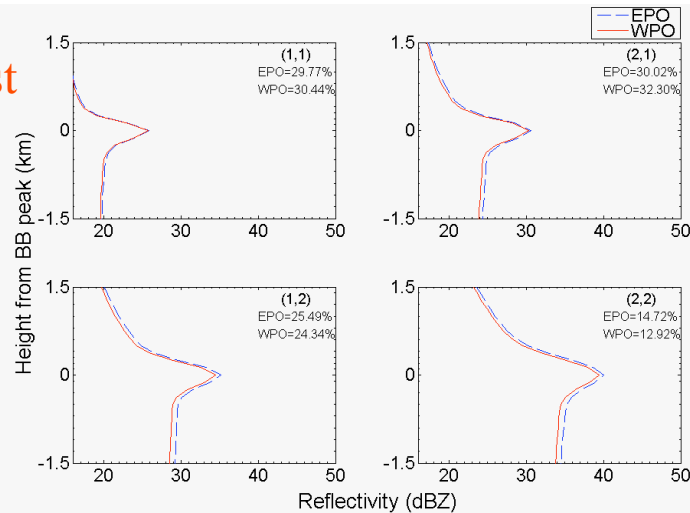
January



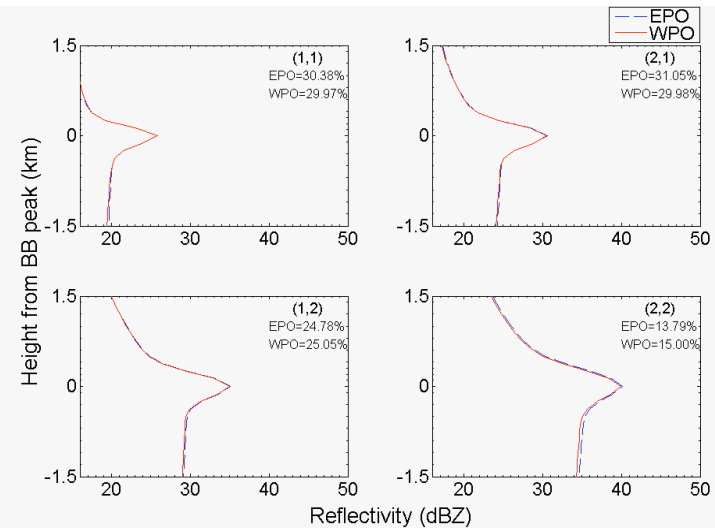
April



August



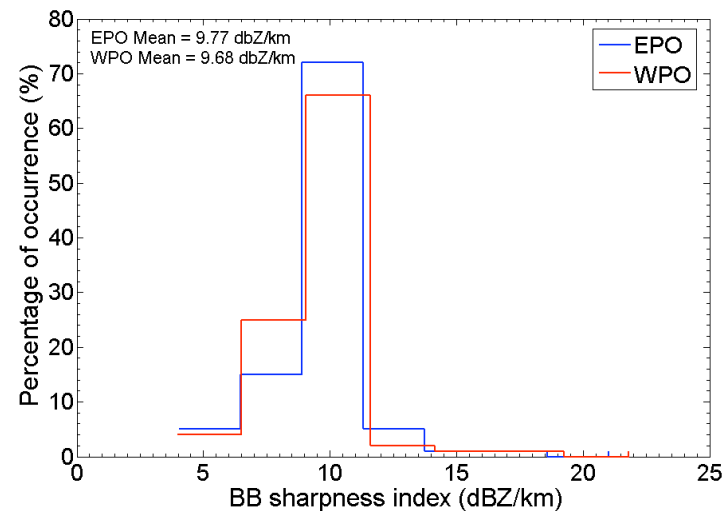
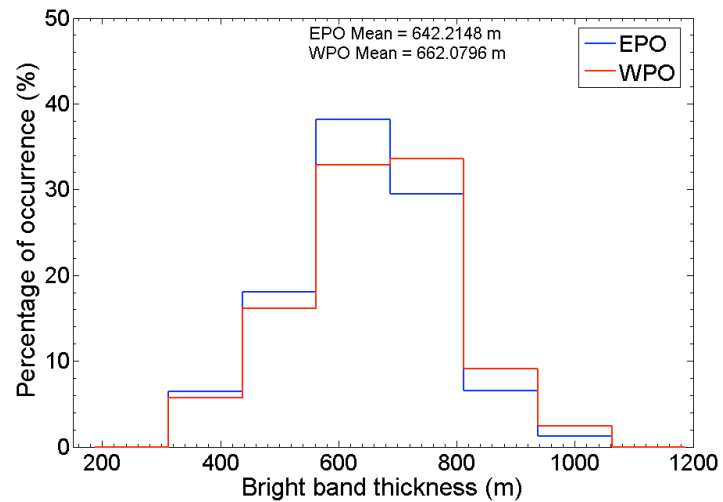
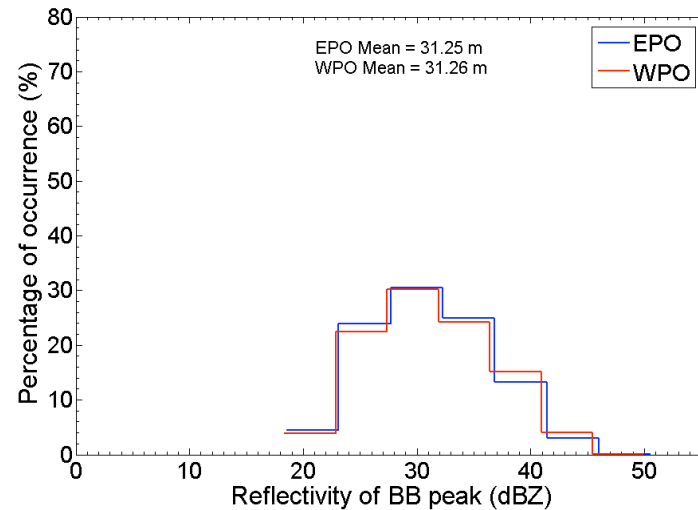
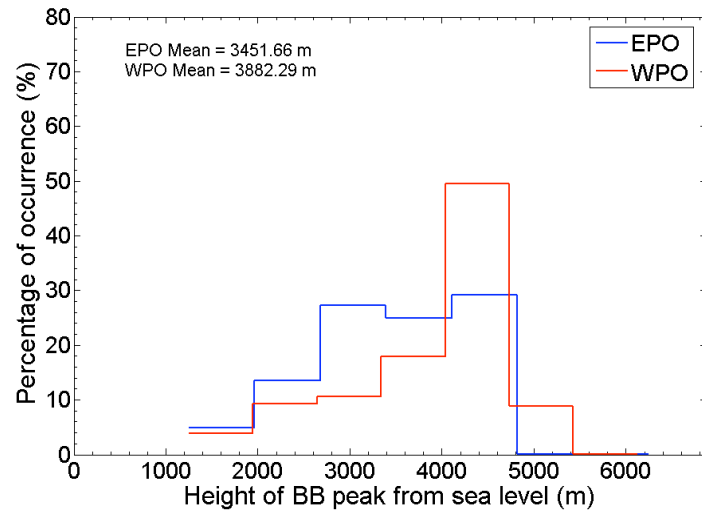
November



- There is slightly difference in reflectivity below height of BB peak in January and August



Comparison BB properties between East and West Pacific Ocean in year 2000

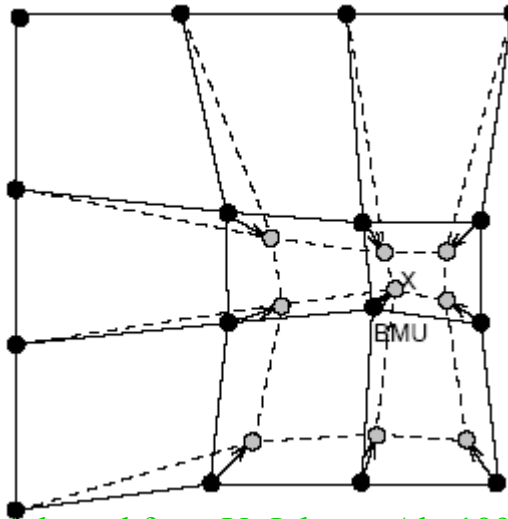




Self-Organizing Map (SOM)

- SOM is an unsupervised neural network
- A SOM consists of neurons organized on a regular low-dimensional grid. Each neuron is represented by d-dimensional weight vector, $m = [m_1 \dots m_d]$, where d equals the dimension of the input vectors.
- The neurons are connected to adjacent neurons by a neighborhood relation which dictates the structure of the map.
- The SOM training algorithm updates the best matching unit (BMU) and its topological neighbors on the map
- The region around the BMU is pulled toward the presented training data

An Example of 2-Dimension rectangular map shape



Neighborhood vectors are adjusted toward presented training vector

(Adopted from V. Juha et. Al., 1999)



SOM training algorithm

1) Determining BMU (Best map unit)

- Calculate Euclidian distance

$$\|x - m_c\| = \min_i \{ \|x - m_i\| \}$$

where m_c is BMU vector, m_i is a prototype vectors and x is input vector

2) Update the prototype vectors

$$m_i(t+1) = m_i(t) + \alpha(t)h_{ci}(t)[x - m_i(t)]$$

where $x(t)$ is an input vector drawn from the input data set at time t .

$h_{ci}(t)$ is the neighborhood kernel around the winner unit c

$\alpha(t)$ is the learning rate

Mostly used neighborhood function is Gaussian in the following form

$$h_{ci}(t) = \exp\left(-\frac{\|r_i - r_c\|^2}{2\sigma(t)^2}\right)$$

where $\|r_i - r_c\|$ is the distance between map units c and i on the map grid

$\sigma(t)$ is neighborhood radius at time t